WELSH JOINT EDUCATION COMMITTEE
General Certificate of Education
Advanced Subsidiary/Advanced

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541/01

PHYSICS

ASSESSMENT UNIT PH1: Waves, Light and Basics

P.M. FRIDAY, 6 June 2003

(1 hour 30 minutes)

Centre Number ....

Candidate's Name (in full) ....

Candidate's Examination Number ....

For Examiner's use only.	
1	
2	
3	
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7	
Total	

INSTRUCTIONS TO CANDIDATES

Write your centre number, name and candidate number in the spaces provided above.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

You are advised to spend not more than 45 minutes on questions 1 to 5.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 90.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Your attention is drawn to the information "Mathematical Data and Relationships" on the back page of this paper.

No certificate will be awarded to a candidate detected in any unfair practice during the examination.

Fundamental Constants

Avogadro constant	N_A	=	$6{\cdot}0 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}6 \times 10^{-19}$ C
Mass of electron	m_e	=	$9{\cdot}1 \times 10^{-31}$ kg
Molar gas constant	R	=	$8{\cdot}3$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	=	$9{\cdot}8$ m s^{-2}
Planck constant	h	=	$6{\cdot}6 \times 10^{-34}$ J s
Speed of light in vacuo	c	=	$3{\cdot}0 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_0	=	$8{\cdot}9 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}

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1. *(a)* Define acceleration. [1]

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(b) An aircraft is towing a glider of mass 204 kg along a level runway. They accelerate uniformly from rest for a time of 15 seconds, until they reach their take-off speed of 45 ms^{-1}. Calculate the glider's acceleration. [2]

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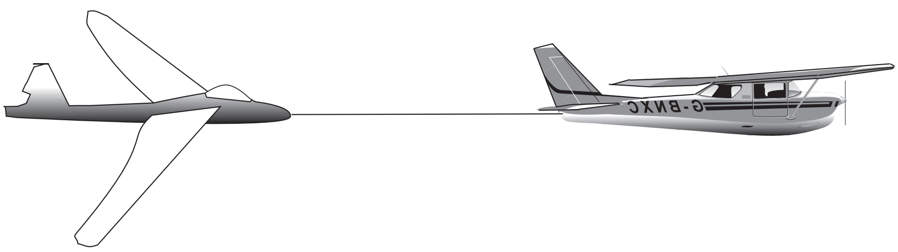

(c) After a while, both the plane and the glider (still attached) fly horizontally **at steady speed** as shown in the diagram above. The glider can be represented by a single point, **G**, as shown below. The tension (**T**) in the cable towing the glider is also shown and is **drawn to scale**. Draw carefully on the diagram below, vectors to indicate the size and direction of the other main forces acting on the glider. (You will need to refer to the list of constants given on page 2.)

SCALE: 1 cm = 500 N

[4]

(d) (i) The cable is disconnected, and the glider released. Calculate the initial deceleration of the glider. [2]

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(ii) Name the force which caused the glider to decelerate. [1]

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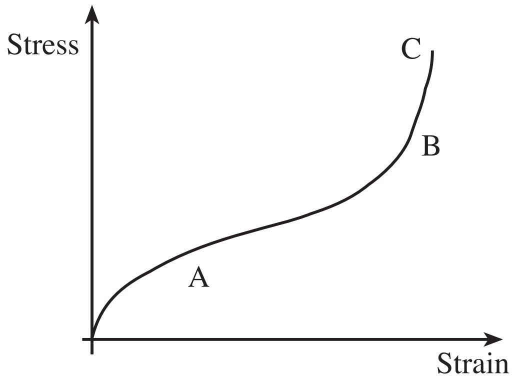
2. A sketch graph of stress against strain for a rubber band is given below.



(a) Explain, in terms of molecules, the shape of the curve in the region

(i) AB, [2]

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(ii) BC. [2]

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(b) Explain why it would not be suitable to draw a stress-strain graph for a copper wire on the same pair of axes as rubber. [1]

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(c) (i) Define the *Young modulus*. [1]

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(ii) State how a stress-strain graph may be used to find the Young modulus of a sample of a material. [1]

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(iii) Hence explain why it is possible to obtain many values of the Young modulus for rubber. [1]

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(d) Car tyres are a composite of rubber and steel.

(i) Give one property of rubber that makes it suitable for use in car tyres. [1]

....

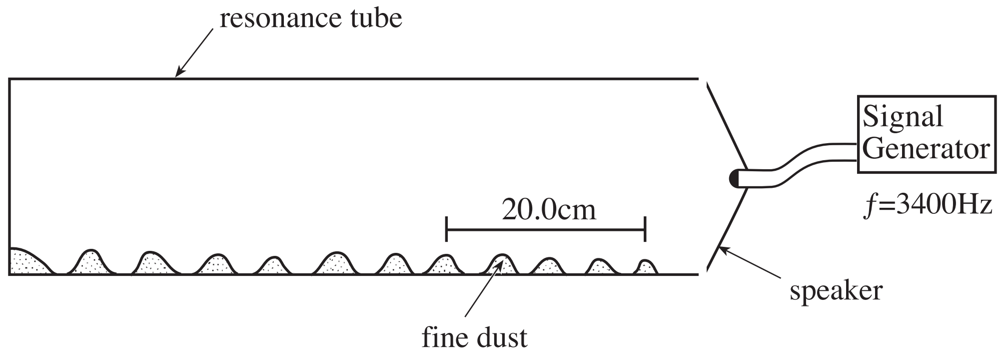
(ii) Give one property of steel that makes it suitable for use in car tyres. [1]

....

3. *(a)* Complete the table below summarizing some of the key differences between progressive and stationary (standing) waves. [2]

Wave property	**Stationary waves**	**Progressive waves**
Amplitude	Zero at the nodes to maximum at the antinodes.	
Wavelength		Distance between two consecutive particles oscillating in phase.

(b) Stationary waves in air can be demonstrated using a transparent closed resonance tube containing a layer of fine dust. At the open end a loudspeaker connected to a signal generator produces sound waves which travel to the closed end of the tube, where they are reflected and interfere with the incident waves. The frequency of the signal generator is varied until, at certain frequencies, stationary waves are formed. These are revealed to an observer when the dust collects **at nodes** in regularly spaced heaps as shown.



(i) Explain why the dust collects at the nodes. [2]

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(ii) Dust heaps are seen to collect when sound of frequency 3400 Hz is played into the end of the tube. The separation between the **first** and **fifth** heap is found to be 20.0 cm. Calculate

(I) the wavelength of the sound waves, [2]

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....

(II) the speed of sound in air. [2]

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(c) Explain why it is not good experimental practice to calculate the wavelength by measuring the distance between adjacent heaps. [2]

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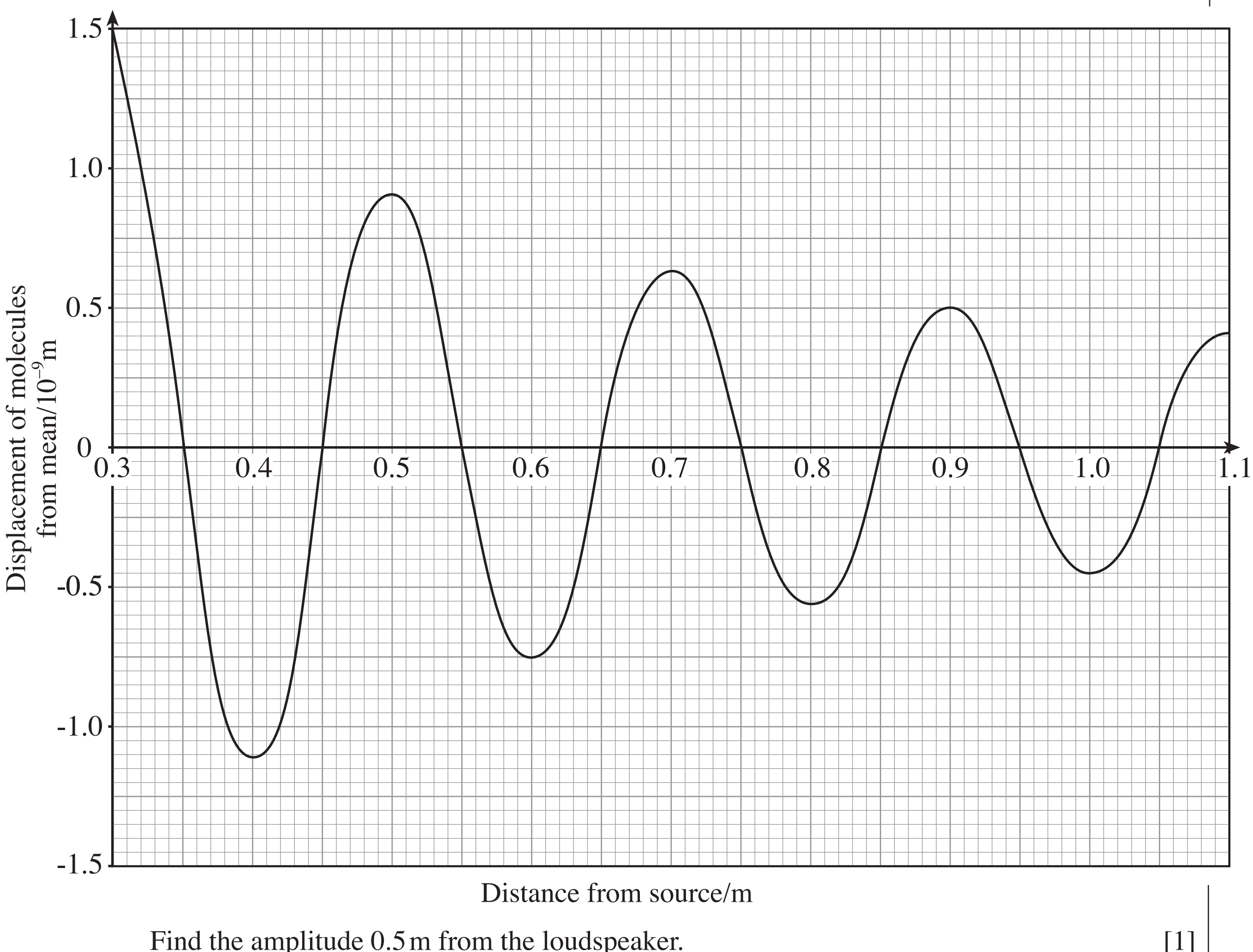
4. *(a)* *Sound is an example of a longitudinal wave*. Explain what is meant by this statement. [1]

(b) (i) The *intensity* of a wave has units of *watts per metre²*. Use this information to define intensity. [1]

(ii) A small loudspeaker emits sound energy uniformly in all directions with a power of 5.0 watts. Calculate the intensity of the sound wave **at a distance of 0.5 m** from the loudspeaker. [Area of spherical wave-front = $4\pi r^2$.] [2]

(c) Part of a graph of particle displacement vs. distance from speaker (at a certain time) is shown below.



Find the amplitude 0.5 m from the loudspeaker. [1]

Turn over.

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(d) The intensity (I) is related to the amplitude (A) according to the following equation

$$\text{Intensity} = k \times (\text{Amplitude})^2$$

where k is a constant.

(i) Use your answers to *(b)*(ii) and *(c)* to find the value of k. [2]

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(ii) At a further distance from the source, the amplitude is found to be reduced by a factor of 10 (i.e. it is 10 times less than the value calculated in *(c)*). Use your value of k to calculate the intensity at this distance. [2]

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(iii) By comparing your answers to *(b)*(ii) and *(d)*(ii) calculate the ratio of intensities. [1]

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5. *(a)* Define *displacement*. [1]

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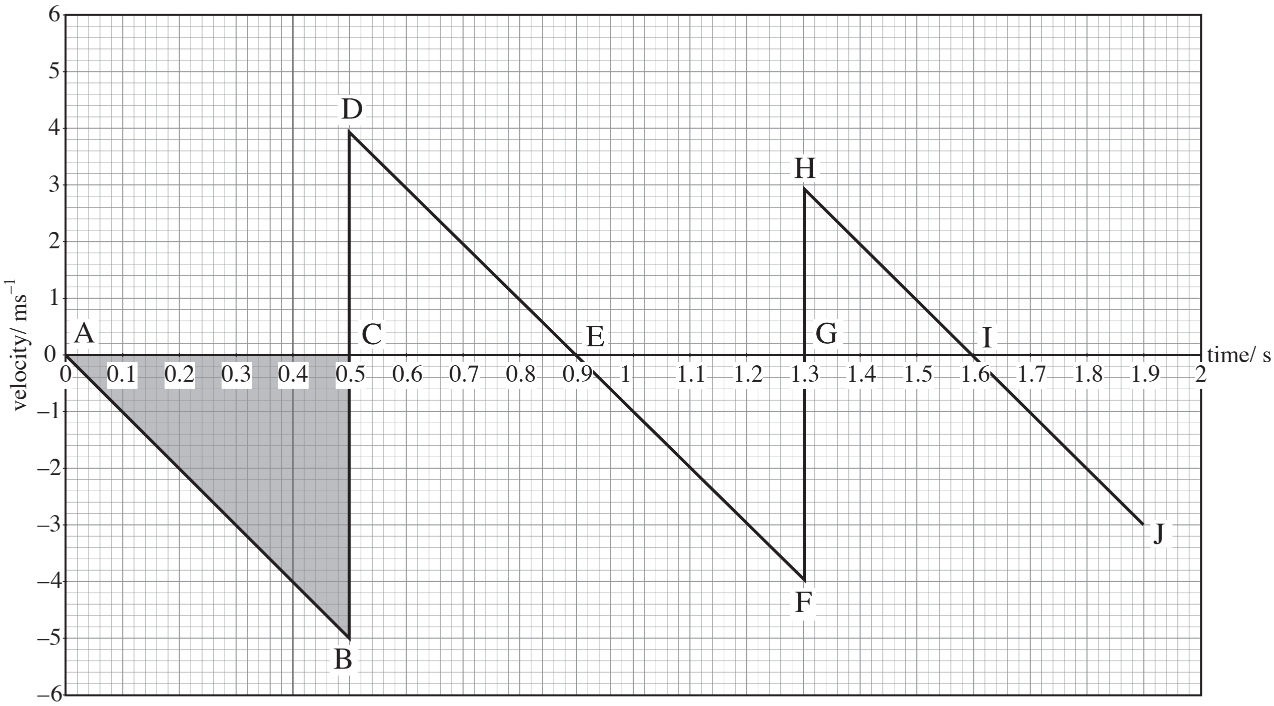
(b) A table tennis ball is dropped onto a horizontal wooden bench and allowed to bounce freely. A simplified velocity-time graph for the first 1.9 seconds of the ball's motion is shown below.



(i) In which direction is the ball moving in part D-E? Give a reason for your answer. [2]

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(ii) What letter represents the highest point reached by the ball after its **second** bounce? [1]

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(iii) What does the shaded area represent? [1]

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(iv) Determine the height from which the ball was dropped. [2]

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(v) Determine the displacement of the ball (from its drop height) after 0.9 seconds. [2]

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(c) Sketch, on the axes below, a graph of acceleration vs time for the first 0.5 s of the ball's motion. [1]

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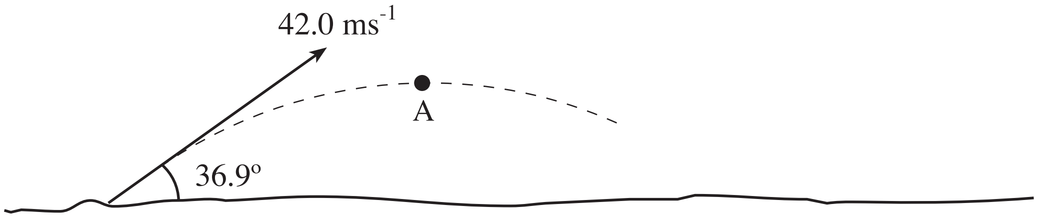
6. *(a)* A golfer strikes a golf ball and gives it a velocity of 42.0 ms^{-1} at an angle of 36.9° to the horizontal. Part of the ball's flight is shown below.



(i) **Show on the diagram**, by means of an arrow, the direction of the ball's velocity at A. [1]

(ii) By resolving, or otherwise, find the ball's

(I) initial vertical component of velocity, [2]

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....

(II) initial horizontal component of velocity. [2]

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....

(iii) The ball's motion can be studied in more detail by considering its **horizontal** and **vertical** components of velocity. Explain why perpendicular directions are chosen when resolving vectors. [2]

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(b) For this part of the question assume that air resistance may be neglected. (You will need to refer to the list of constants given on page 2.)

(i) By considering the vertical component of velocity, calculate the maximum height reached by the ball. [3]

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(ii) Calculate the time of flight (i.e. time taken to reach the ground again). [3]

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(iii) Calculate the **horizontal** distance travelled by the ball in this time. [3]

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(c) In fact air resistance does have a significant effect on the flight of a golf ball. Discuss, giving clear reasons, how air resistance might affect your answer to

(i) *(b)*(i) i.e. the maximum height reached by the ball, [2]

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(ii) *(b)*(ii) i.e. the time of flight. [2]

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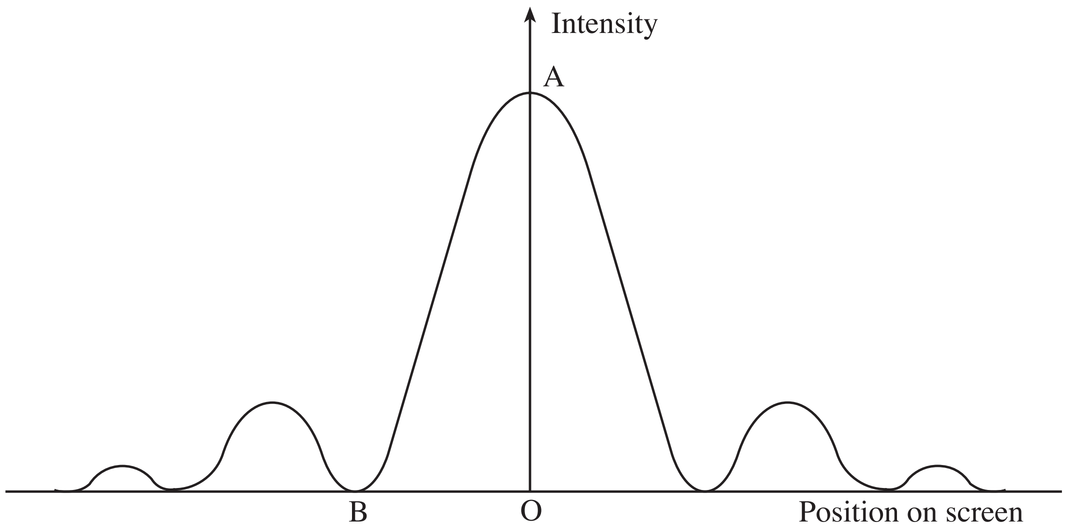
7. *(a)* The graph shows the intensity pattern produced when light from a monochromatic (single wavelength) light source is diffracted through a narrow single slit onto a distant screen.



(i) Describe the appearance of the light on the screen corresponding to point

(I) A, [1]

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(II) B. [1]

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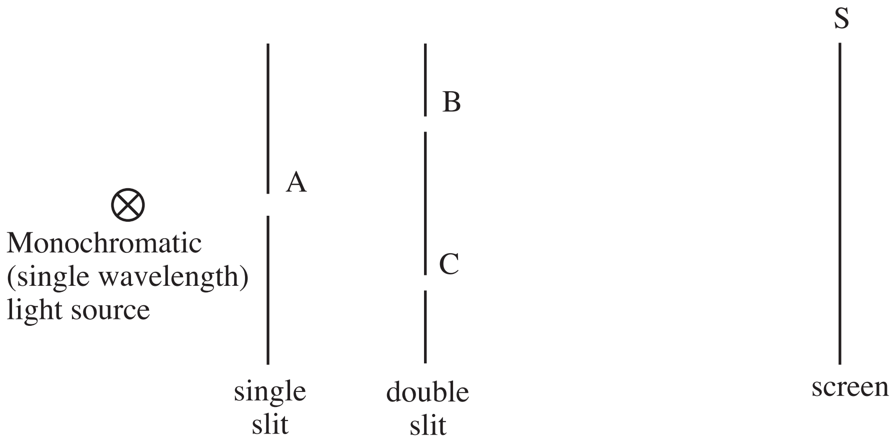
(ii) Label on the graph **with the letter C**, another point where the appearance of the light on the screen will be the same as that at B. [1]

(b) At the beginning of the nineteenth century Thomas Young used apparatus similar to the following to produce a visible interference pattern on a screen S.

Not to scale



(i) B and C act as *coherent* sources. Explain what is meant by *coherent*. [1]

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(ii) Explain the purpose of the single slit A in this arrangement. [2]

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(iii) A series of bright and dark fringes is seen on the screen. Name the phenomenon that gives rise to these fringes and explain how the **bright fringes** are formed in terms of path difference. [3]

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(iv) Young's double slit experiment has been described by scientists as being '*crucially important in providing evidence about the nature of light*'. What does the experiment tell us about the nature of light? [1]

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(v) In this case, the slit separation BC is 0.80 mm, the distance from slits to screen is 2.0 m and the distance between the centres of two adjacent bright fringes is 1.5 mm. Show that the wavelength of the light from the source is 6.0×10^{-7} m. [3]

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(c) (i) A student replaces the double slit arrangement with a diffraction grating. Bright lines are now observed on the screen. The angular position of the **second order** line is found to be at 26.4° from the centre. Calculate

(I) the distance between the diffraction grating slits, [2]

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(II) the highest order seen. [3]

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(ii) Hence suggest why the student could have measured the wavelength of light more accurately using a diffraction grating rather than by using Young's double slits. [2]

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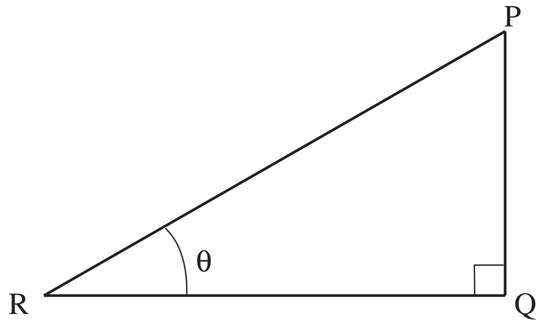
Mathematical Data and Relationships

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	µ
10^{-3}	milli	m

Multiple	Prefix	Symbol
10^{-2}	centi	c
10^{3}	kilo	k
10^{6}	mega	M
10^{9}	giga	G
10^{12}	tera	T
10^{15}	peta	P

Geometry and trigonometry



$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{RQ}{PR}, \quad \tan\theta = \frac{PQ}{RQ}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$PR^2 = PQ^2 + RQ^2$$

Areas and Volumes

Area of a circle $= \pi r^2 = \dfrac{\pi d^2}{4}$

Area of a triangle = ½ base × height

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$